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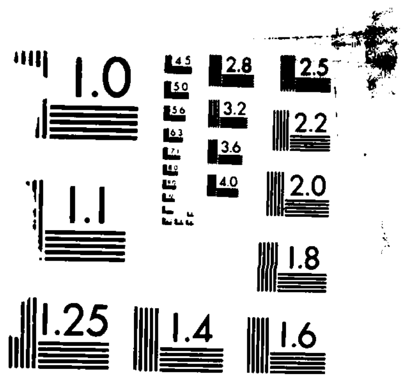

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- The following conclusions are presented: (1) it is feasible to construct an offshore bar with no special dredge plant or procedures; (2) sediment movement from bar will be minimal; (3) it is expected that bar will induce some wave energy attenuation, thereby providing benefits to the shore zone; (4) bar will not affect normal shore processes; (5) construction of bar represents a beneficial use of dredged material as compared to deposition in deep ocean waters.

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STUDY REGARDING UTILIZATION OF DREDGED MATERIALS TO CONSTRUCT AN OFFSHORE BAR

By

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STUDY REGARDING UTILIZATION OF DREDGED MATERIALS TO CONSTRUCT AN OFFSHORE BAR

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STUDY REGARDING UTILIZATION OF DREDGED MATERIALS TO CONSTRUCT AN OFFSHORE BAR

1.0 INTRODUCTION --

The Norfolk District of the U. S. Army Corps of Engineers is conducting an extensive study concerning an increase in dimensions for the Thimble Shoal and connecting channels which serve navigation interests in the lower segment of the Chesapeake Bay and particularly the Norfolk-Portsmouth-Newport News areas. General features of the area are shown on Figure 1.

One component of this study concerns the effective utilization of the material dredged from the easterly segments of the Thimble Shoal and ocean approach channels. The quantity of dredged material involved will be dependent on final decision of channel cross-section, however, the preliminary estimate is in the order of thirty million cubic yards for a controlling channel depth of fifty-five feet and a channel width which will accommodate two way ship traffic. It is also estimated that the dredged material would be non-polluted sand of fine to medium size characteristics. Of the alternatives considered by the Norfolk District for disposal of the dredged material, it was decided that further study and evaluation would be undertaken for placement of the material in an offshore submerged bar configuration. Conceptually the offshore bar would be located generally parallel with the Virginia Beach-Cape Henry Coastline and extend northerly from the existing Dam Neck offshore disposal site with a northern terminus of the bar compatible with offshore physical factors in the Cape Henry area as well as the location of the southerly ocean navigation approach channel into Chesapeake Bay.

There are many components of this extensive study being carried out by the Norfolk District and the report herein is considered to be only a segmental input to the overall study.

2.0 SCOPE OF STUDY

In accordance with guidance provided by the Norfolk District, the scope of this report is to present a review of existing literature that is pertinent to offshore bar construction, provide an analysis of offshore bars to coastal processes and offshore bar construction techniques, and provide conclusions and recommendations with respect to requirements for the study and analysis of offshore bar demonstration projects.

3.0 LITERATURE REVIEW

This literature review is limited to projects wherein a component of the project involved construction of an offshore bar whose physical features and resultant behavior are pertinent to the present study being conducted by the Norfolk District. With respect to literature review of other physical factors, it is recognized that extensive documented data presently exists on wave climates, meteorological conditions, currents, and sediments for the Chesapeake Bay entrance and contiguous Atlantic Ocean areas. A review and analysis of this literature is not addressed herein as it is understood that compilation of these data will be accomplished by the Norfolk District as a part of the overall study of the channel deepening project.

3.1 Projects in the United States Involving Underwater Bar Construction.

3.11 Test of Nourishment of the Shore by Offshore Deposition of Sand, Long Branch, New Jersey - This project is reported on in Technical Memorandum No. 17 and No. 62 of the Beach Erosion Board, Office of the Chief of U. S. Army Corps of Engineers. This experiment to nourish the Long Branch shores by the offshore deposition of sand to create an underwater mound parallel with the shore, was carried out in 1948. TM 17 covers the initiation (April 1948) of the project to October 1948 and TM 62 is a restudy of the test site in October 1952. The sand was dredged from the entrance channel to New York Harbor, near Sandy Hook, N. J., by a hopper dredge and transported southerly to a designated placement area offshore of Long Branch, N. J. Approximately 602,000 cubic yards were placed which created a mound 7 feet high, 750 feet wide, and 3,700 feet in longshore length. The mound was located about 2,600 feet offshore in a water depth of 38 feet as referred to mean low water datum. Samples from each dredge load indicated the placed sand to have a mean diameter of 0.34 millimeter. Sampling of the offshore bottom material in the test area indicated a mean diameter of 0.39 millimeter in 1948 and 0.32 millimeter in 1952.

Survey data of the offshore mound area in October 1948 and October 1952 indicated about 6 percent (38,000 cubic yards) had been transported out of the initial stockpile area. The 1952 restudy of offshore test area as well as the beach and nearshore area indicated that although the offshore constructed

bar lost only about 6 percent of its volume from October 1948 to October 1952, severe shoreline erosion prevailed during this period, and it appeared that the offshore stockpiling operation had little effect on the littoral processes in the area.

3.12 Report on Cooperative Beach Erosion Control Study at Santa Barbara, California, Corps of Engineers, Nov. 1946 - This report indicates that an attempt was made to nourish the beach at Santa Barbara in September 1935 wherein 202,000 cubic yards of sand were deposited by a hopper dredge in 20 feet of water depth (mlw) to form an underwater mound. The 1946 report states the mound constructed in 1935 has remained exceptionally stable in that profile data indicates the crest elevation of the mound is at no point more than a foot below the 1937 elevation. The profile data also indicated that the trough between the mound and shoreward slope of the natural bottom had been filled by a depth of 2 to 3 feet in most places.

3.13 Report on Cooperative Beach Erosion Control Study at Atlantic City, New Jersey, Corps of Engineers, April 1947 - This report indicates that an attempt was made to nourish the beach at Atlantic City. Sand removed by hopper dredge from the navigation channel serving the harbor was deposited in 15 to 25 feet of water depth (mlw) offshore of the beach area. 792,000 cubic yards were deposited in the period April 1935 - March 1936; 900,000 cubic yards deposited during Feb-Sept 1937; 500,000 cubic yards deposited during Aug-Dec 1938; and 1,362,000 cubic yards deposited during Aug-Sept 1942. The 1947 report indicates that of the sand deposited offshore during the period 1935-1942 (about 3.5 million cubic yards) there is no evidence that any substantial quantity of sand has moved to the beach zone by natural processes.

3.2 Projects Outside United States Involving Underwater Bar Construction.

3.21 Underwater Mound For the Protection of Durban Beaches - This project, at Durban, South Africa, was reported on by J. A. Zwamborn in the proceedings of the American Society of Civil Engineer's 12th Coastal Engineering Conference, September 1970. At the entrance to Durban Harbor the longshore littoral material transport is from south to north and, due to impoundment of littoral drift by the harbor entrance channel and protective jetties,

shore erosion prevails northerly of the Harbor. Since large amounts of sand are dredged by hopper type dredges from the entrance and interior channels of Durban Harbor, a plan was developed for placement of the dredged materials to form an underwater mound oriented parallel with the Durban beaches. After two-dimensional model studies the final scheme was to have the crest elevation of the mound at 7.3 m below Low Water Ordinary Spring Tide (LWOST) which was sufficient water depth for operation of the loaded hopper dredges and hopper barges. The crest width was to be 61 m, the side slopes to be about 1 on 25, the longshore length of the mound to be 4.5 km, and the total quantity of sand required was about 8,000,000 cubic meters. The profile of the mound, relative to the natural offshore ocean bottom, would be located between the 10 and 15 meter depth contours which would position the mound about 1100 to 1500 meters offshore of the LWOST line of the beach.

Sand dumping started in June 1966 and by May 1970 a total of 2,500,000 m^3 had been placed in the project area. Sampling in the hoppers of the dredges indicated a mean grain size range from 130 to 495 microns. The mean grain size of the sand composing the sea-bottom in the mound area varied between 212 and 340 microns. The quantity placed by May 1970 created about 1500 m of the longshore length of the underwater mound. The crest elevation was reasonably close to the design (7.3 m below LWOST), the crest width was reasonbly close to design (61 m), and side slopes comparable to design (1 on 25).

The report, as presented in above reference ASCE Proceedings, further conveys the effectiveness of the underwater sand mound in protecting the Durban Beaches and stability of the mound under wave conditions.

3.22 Copacabana Beach, Rio de Janerio, Brazil - The Hydraulics Department, Laboratorio Nacional de Engenharia Civil, Lisboa, Portugal has produced many reports on the 1970 constructed beach fill project at Copacabana Beach. That laboratory carried out extensive model studies and was involved in the planning, design, and construction of this beach fill project. General project features are mentioned herein, because an offshore submerged bar was utilized as a component of the beach filling procedure.

Copacabana Beach is crescent in plan view with headlands at the northerly and southerly limits of the beach sector. The beach filling procedures utilized

a hopper dredge to construct an offshore submerged bar or berm parallel with the shore and utilized a cutter-suction dredge to fill the profile sector from the offshore bar to the beach as well as the widening of the beach to desired dimensions. The borrow material for the hopper dredge operation was from the offshore zone northerly of the project limits and the borrow for the cutter-suction dredge operation with a long discharge line was from an inshore semi-protected area also northerly of project limits. The hopper dredge was of special design in that unloading operations involved the heading of the vessel shoreward thence through a combination of grounding the vessel and bin discharge via sliding doors, the load could be spread over the designed berm area which was located between approximately the 15 and 20-foot depth contours.

Reportedly, the offshore submerged bar was constructed to desired dimensions, and the bar maintained its geometry for the hydraulic placement of sand shoreward thereof. The project involved the placement of approximately four million cubic yards of sand and past monitoring indicates it is a very successful project.

3.23 Other Foreign Countries Contacted - Professor Richard Silvestor, Department of Civil Engineering, University of Western Australia, was contacted regarding any projects in Australia wherein the disposal of dredged material was utilized for the construction of an offshore bar system to protect the shore zone. His reply was that to his knowledge no project of this type has been undertaken in Australia. The only attempt he was aware of to stabilize a coast by offshore mound deposition is at Durban, South Africa.

Professor Kiyoshi Horikawa, Department of Civil Engineering, University of Tokyo, indicated that ten to twenty years ago the materials dredged from navigation channels and harbors were disposed in deep waters. Due to the need for creating reclaimed land and many of the sediments are contaminated, placement of the dredged material in prepared upland disposal sites is now the more common practice. His response indicated that a plan to construct an underwater bar with dredged materials has not been practiced in Japan.

Contact was made regarding the construction of offshore submerged bars in the United Kingdom, however responses to the inquiry were not received at the time of preparation of this report. Informal contact indicates there

have been no projects carried out in the U.K. involving the utilization of dredged material in the construction of an offshore bar for shore protection purposes.

3.3 Analysis and Discussion of Literature Reviewed.

The number of documented projects involving the use of dredged material to construct an offshore submerged bar for shore protection or any other purpose is limited. The most probable reason for the limited amount of available literature on this subject is that by theory, and by results of demonstration projects carried out some 45 years ago, indications are that to achieve immediate benefits to the beach, the constructed bar must be positioned within the active (shallow water) foreshore zone. Placement of dredged material in this zone necessitates special dredging plant and operational procedures, thus, economics favor offshore disposal in deep water or placement directly on the shore via re-handling or use of a cutter-suction dredge, depending on site specific conditions.

At least two important points are conveyed in the reviewed literature. First, with adequate water depth for a loaded hopper dredge to discharge its materials, there are no apparent operational problems in the construction of a mound or bar. In all cases, the resultant constructed bar could be clearly and somewhat accurately defined by normal hydrographic survey techniques. This leads to the second point in that post construction surveys indicate the bar maintains its geometry for an indefinite period of time. Pertinent to this indication is that the median grain size of the sand utilized to construct the bar was generally coarser than the sand composing the natural bottom in the area of the bar.

Of the projects reviewed, the Durban, South Africa project would appear to be more directly comparable to the Norfolk District's concept for disposal of the material dredged from the entrance channel deepening and subsequent maintenance. Documented results of the Durban project, to 1970, indicate that construction of the submerged bar to design dimensions can be readily accomplished and post construction monitoring to that point in time indicates positive protective benefits to the beach and foreshore zones. With respect to the indicated shore protection benefits, it is unfortunate that efforts to obtain

1970 - to the present documentation of the Durban project have not been successful as of the time of preparation of this report. The cited projects at Long Branch, N. J., Santa Barbara, CA, and Atlantic City, N. J. indicate no apparent shore protection benefits from the offshore constructed bars; therefore, the early results of the Durban project may not be representative of the longer time frame. This is suggestive that if an offshore submerged bar is constructed northerly from the Dam Neck disposal site, in water depths greater than, say, 30 feet, predicted shore protection benefits may be marginal. Of all the projects reviewed, the submerged bar did not cause any adverse effects to the beach and foreshore zone, and this finding would also be predictive for the Norfolk District's concept of bar construction offshore of the Virginia Beach shore sector.

4.0 ANALYSIS AND DISCUSSION OF OFFSHORE BARS TO COASTAL PROCESSES AND OFFSHORE BAR CONSTRUCTION

There have been many laboratory and field studies, with resulting reports, on the relationship of sand bars in the nearshore zone to coastal processes. The literature on this subject is extensive. Several physical factors influence the creation, behavior, and movement of these bars; however, the dominant factors are the wave height to length ratio, sand characteristics composing the beach and nearshore bottom which, in turn, is related to the slope of the bottom, and water depth as well as water level fluctuations. The actual mechanism of the interaction between wave generated currents along the bottom and the movement of sediments is not completely understood, however, given the parameters of the incident wave (forcing element) and parameters of the sediment and related factors (response element) the quantitative resultant sediment movement is predictive. For example, and in general, if the incident wave height is large relative to the wave length, the orbital velocities generated by the wave crest will dominate and bottom sediments will be transported in a seaward direction. If the wave height is small relative to the wave length, the orbital velocities generated by the wave trough will dominate and bottom sediments will be transported in a landward direction. Accordingly, a bar or bar system may move seaward or shoreward, depending on the magnitude of the wave height to length ratio. This simple explanation

is pertinent to the planning of offshore bar construction in that, depending on the site specific area, there will be a water depth zone where (with respect to time) substantial bottom changes will prevail shoreward of that zone and very little bottom change seaward of the zone. If, for example, at a specific shore station (range line) repetitive profile data (say, several surveys over a 20-30-year period) extending from the beach to the offshore zone are displayed on a single plot, the probability is very high that there will be a clear definition where the profile lines will "come-together" and be more or less common as the lines continue into deeper water. Thus, if a submerged sand bar is constructed seaward of the depth zone where the profile lines "come-together", the bar should maintain its constructed geometry. Conversely, if bar construction is landward of this depth zone, dissipation of the bar's geometry will be related to the decrease in water depth in which the bar is positioned.

As indicated, the depth zone at which plotted comparative profile data will "come-together" is site specific, and, obviously dependent on the prevailng littoral force and response elements. Regionally, this depth zone is in the 8 to 12-foot range along the Gulf Coast and Great Lakes, in the 30 to 40-foot range along the Pacific Coast, and in the 18 to 25-foot range along the Atlantic Coast. For the Virginia Beach sector of coast the depth zone is in the 18 to 20-foot range. Since the proposed bar construction northerly of the Dam Neck disposal site to the Cape Henry vicinity would be positioned between the 30 and 45-foot depth contours (see Figure 2), transport of material out of the bar area by wave induced currents should be minimal. The constructed bar will be subjected to tidal flood and ebb currents prevailing in the general area of the Chesapeake Bay entrance. The results of current measurements presently being made in the proposed bar area by the Norfolk District should provide a more confident means of predicting the tidal current influence on the constructed bar. Existing data for the general area where the bar would be positioned, indicate bottom currents range from 0.5 to 2.0 feet per second. Currents of this order of magnitude are above the threshold velocity to induce movement of sand in the 100 to 200 micron size range. Orientation and layout of the proposed bar will, in general, be

compatible with the flow lines of the flood and ebb currents which is favorable with respect to the resultant or net effect that tide induced currents will have on the constructed bar.

With respect to the feasibility of constructing the offshore bar in the study area (refer to Figure 2) past experiences indicate it would be very feasible. Also, no special or restrictive dredging plant or operational procedures are required to accomplish the construction. This is further confirmed by recent tests carried out by the Norfolk District wherein material dredged from the Thimble Shoal channel was deposited in the Dam Neck disposal site to create a mound or bar of about 11 feet in height. Continued monitoring of this constructed bar will provide valuable guidance on refinement of design of the bar extension northerly of the Dam Neck disposal site. Subject to guidance from the documented behavior of this bar as well as guidance from other field data presently being obtained in the study area, the planning of the cross-sectional geometry for the northerly bar extension between the 30 and 45-foot depth contours would involve a crest elevation of approximately (-)25 feet as referred to mlw, the crest width could be in the order of 4000 feet, and side slopes of approximately 130:1. Depending on the northerly terminus of the bar offshore of the Cape Henry sector, the volume of material contained in the bar would be in the order of 40 million cubic yards.

As per analysis of presently documented projects pertinent to the proposed bar construction, movement of the bar material in a shoreward direction may be minimal and difficult to quantify. Although predictive benefits of shore protection to the Virginia Beach-Cape Henry coastal sector cannot be quantified it is certain that the constructed bar would be beneficial during periods of severe strom wave attack. As far as it can be determined, the constructed bar would cause no adverse effects to the shore sector.

5.0 CONCLUSIONS AND RECOMMENDATIONS WITH RESPECT TO REQUIREMENTS FOR THE STUDY AND ANALYSIS OF OFFSHORE BAR DEMONSTRATION PROJECTS

Review and analysis of projects directly pertinent to the proposed bar construction and discussion of related coastal processes leads to the following conclusions:

- It is feasible to construct the offshore bar and no special dredge plant or operational procedures will be required in the construction;

- The bar will be located seaward of the active zone with respect to the nearshore bottom profile and material movement from the bar by wave induced currents will be minimal;
- Benefit to the shore resulting from the bar construction cannot be quantified, however, judgement is that the bar will induce some wave energy attenuation, particularly during storm wave conditions, thus the shore zone will derive benefits;
- The bar will not adversely affect normal shore processes; and
- Utilization of the material excavated from the navigation channels to construct an offshore bar is a beneficial use as compared to deposition in deep ocean waters where no apparent benefits could be derived.

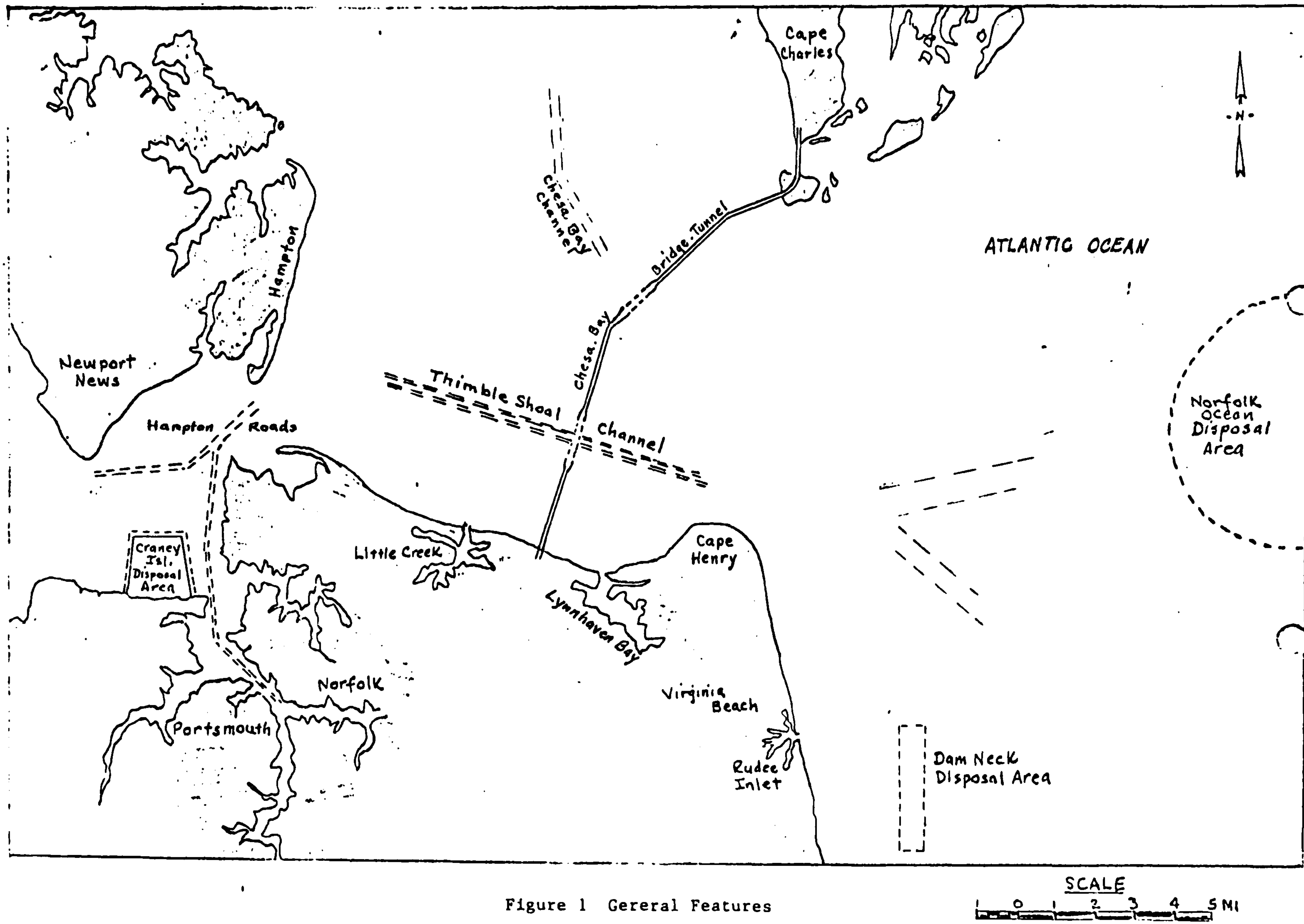
With respect to recommendations on requirements in the study and analysis of an offshore bar demonstration project, it is recognized that through the assistance of CERC and other offices, the Norfolk District has developed a "Plan of Study" for the channel deepening project and construction of the offshore bar, and certain implementation of the study is presently underway. In view of participation of the preparer of this report in the above referenced "Plan of Study", recommendations on requirements that follow are not detailed and pertain only to the physical factors:

o Data Base - Evaluation of adequacy of existing data and procurement of new or supplemental data must be coordinated so it will serve requirements for preparation of detail project planning and design, and, to serve as a base for monitoring and evaluation during project construction and throughout the post construction period.

In this respect, recommended requirements are directly related to decision making, thus, they are judgmental. In the utilization of the data base for preparation of detail project planning and design, a decision must be made on each data set that it adequately quantifies and is representative of that physical factor in the project area. Concurrently, a decision must be made that it (each data set) is adequate to serve as a base or reference with regard to quantification and evaluation of a change of that physical factor

and respective relationship with the project.

o Monitor Study Flexibility - In conjunction with establishment of the data base, it is recommended that the plan for monitoring of components of the project contain adequate flexibility and authorization to modify the planning for purposes of better quantification of physical changes attributal to the project.



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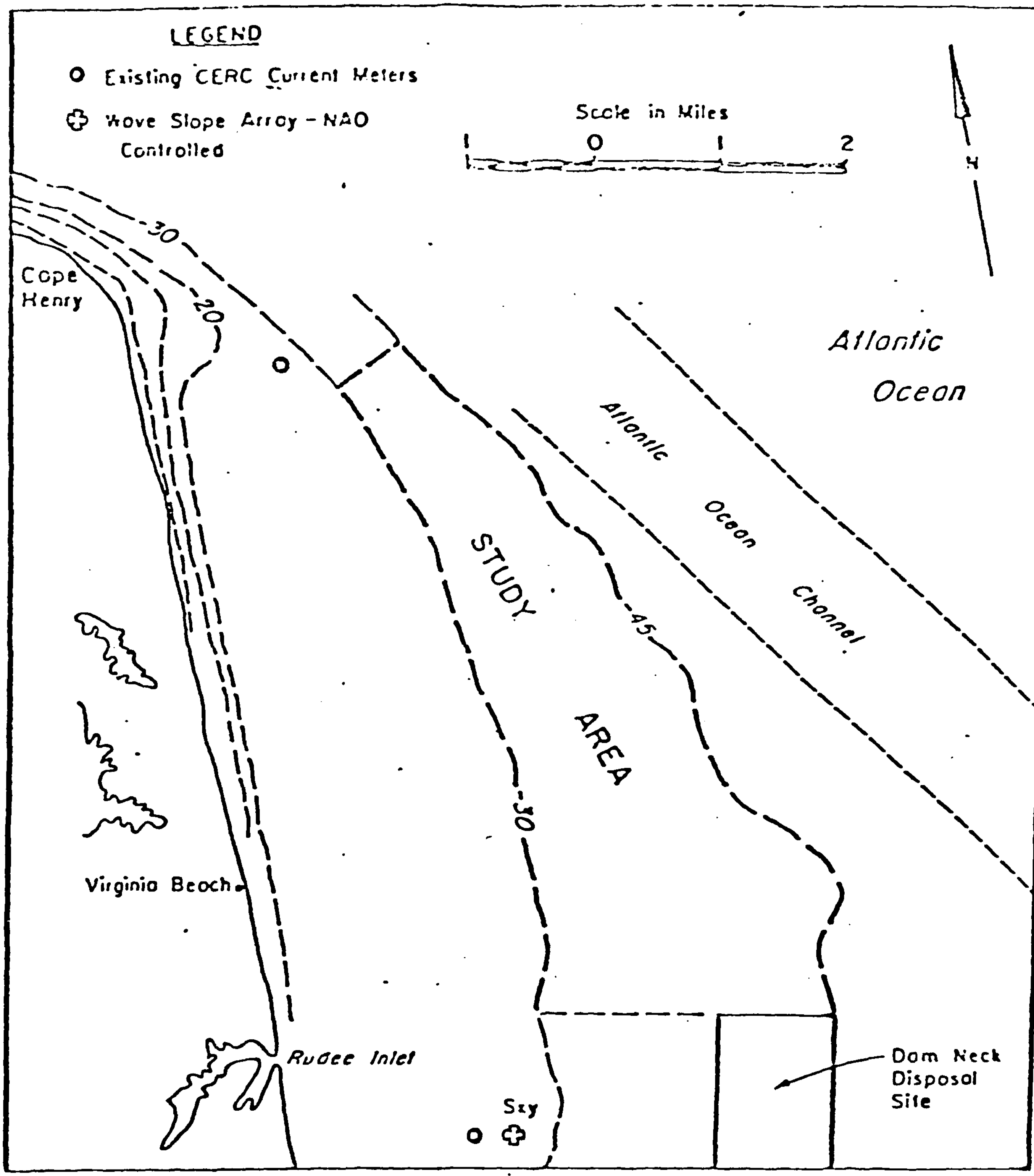

FIGURE 2 Location diagram.

(From CERC Plan Of Study)

George M. Watts, P.E.
B.S., M.S.

EDUCATION AND PROFESSIONAL QUALIFICATIONS

Mr. Watts received his academic training in civil engineering from Brown University, Providence, Rhode Island. His post-graduate work at the University of Minnesota, Minneapolis, Minnesota, included research in water resources development at the University's St. Anthony Falls Hydraulic Laboratory. His major interests included open channel flow and fluvial hydraulics. Mr. Watts has over 35 years of managerial and technical experience in coastal, hydraulic and environmental engineering.

EXPERIENCE

Prior to retirement from the Federal Service in 1978, Mr. Watts was Chief of the Engineering Development Division of the U. S. Army Corps of Engineers Coastal Engineering Research Center. In that capacity, he was responsible for the staff support and management of studies and projects involving all aspects of coastal engineering, flood control, navigation, and power, including the review of related environmental impact statements and assurance that all project studies are carried out in compliance with all Federal and local government regulatory policies and in compliance with the Principles and Standards set forth by the Water Resources Council. He served as a consultant for the Chief of Engineers to all of the Corps Field Offices and for many departments in the Federal Government on engineering problems on a world-wide basis. This included the study and development of solutions to coastal engineering problems in the Azores, United Kingdom, the Netherlands, Germany, France, Portugal, the Red Sea and Persian Gulf sectors of Saudi Arabia, the Arabian Sea and Bay of Bengal coasts of India, South Vietnam, Thailand, Philippines, Japan, Marshall Islands, and Islands in the West Indies. He supervised the preparation and publication of the Center's "Shore Protection Manual", which is internationally recognized and utilized by engineers for technical guidance in developing solutions to coastal engineering problems.

Since 1978, Mr. Watts has managed and provided the technical guidance to clients of a number of coastal engineering projects located on the Atlantic, Gulf, Pacific, and Great Lakes shoreline of the United States.

Mr. Watts is a registered professional engineer. He is a member of the American Society of Civil Engineers, the Permanent International Association of Navigation Congresses, the American Geophysical Union, American Association of Port Authorities, the International Association of Hydraulic Research, the American Shore and Beach Preservation Association, and the Western Dredging Association of which he is the Executive Secretary.

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